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4K4

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## (54) IMPROVEMENTS IN OR RELATING TO LUMINESCENT SCREENS

(71) We, THE GENERAL ELECTRIC COMPANY LIMITED, of 1 Stanhope Gate, London W1A 1EH, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to luminescent screens of the kind comprising a phosphor layer supported on a transparent substrate, usually a glass plate, and is more particularly, but not exclusively, concerned with electroluminescent panels.

It is an object of the present invention to provide an improved form of luminescent screen capable of exhibiting high contrast in operation, whereby the visibility of images on the screen under high ambient lighting conditions is improved, by reducing the amount of light specularly or diffusely reflected from the screen.

According to the invention, a luminescent screen comprises one or more plates of rigid transparent material and, supported on said plate or plates, a layer of phosphor and three layers each capable of modifying the transmission of light there-through, which layers are disposed parallel to the phosphor layer and consist of firstly, disposed furthest from the phosphor layer and constituting the front face of the screen, a broad-band anti-reflection layer which is capable of preventing most of the specular reflection, from the front surface of the screen, of a wavelength band substantially corresponding to the visible spectrum, secondly a circular polariser, and thirdly, disposed nearest to the phosphor layer, a band-pass interference filter which permits the passage therethrough of light only of wavelengths corresponding to the whole or part of the emission of the said phosphor, the screen being so arranged that, in use, the incident ambient light falls

directly upon the anti-reflection layer.

The anti-reflection layer may be formed directly on a substrate consisting of a transparent plate as aforesaid, or alternatively the circular polariser, or both the circular polariser and the interference filter, may be interposed between the anti-reflection layer and such substrate. In order to prevent most of the specular reflection of a broad wavelength band substantially corresponding to the visible spectrum the anti-reflection layer should be substantially matched in respect of refractive index, in known manner, to the interface between air and the immediately underlying layer, whether this is a transparent substrate or the circular polariser.

In operation of a luminescent screen in accordance with the invention, the ambient light incident upon the screen first passes through the anti-reflection layer, which is matched, as indicated above, to the interface between air and the underlying layer so as to eliminate nearly all of the specular reflection from the front surface of the screen.

The incident light then falls upon the circular polariser, with or without first passing through a transparent support plate or substrate, and since this incident light is naturally randomly polarised, up to approximately 50% of the light passes through the circular polariser, the remainder being absorbed. The light passing through the polariser and hence incident upon the interference filter is specularly reflected by the filter, except for light of wavelengths corresponding to the pass band of the filter; the light reflected by the filter, which has already been circularly polarised, undergoes a change of "handedness" on specular reflection, and is therefore absorbed in the circular polariser. The proportion of the incident light which passes through the interference filter, and

which is therefore of wavelengths corresponding to the phosphor emission, may be partially specularly reflected from any subsequent interface in the screen structure, such reflected light also being absorbed in the circular polariser; the remainder of the light passing through the filter is diffusely reflected from the phosphor layer and, since diffusely reflected light is randomly polarised, this reflected light is only partially absorbed in the circular polariser, up to approximately 50% of this diffusely reflected light returning through the polarizer to the face of the screen.

It will thus be apparent that, by using the particular combination of light transmission modifying layers specified, in accordance with the invention, the diffuse background luminance of the screen, as viewed by an observer, will be reduced to a fraction of that which would be produced by the full incident light, which fraction, before correction for visual efficiency (depending upon variation in eye sensitivity to different parts of the spectrum), corresponds to approximately a quarter of the ratio of the pass band width of the interference filter to the band width of the incident light; the contrast of the screen in operation will be correspondingly increased. The degree of improvement obtained will of course depend upon the width of the filter pass band and hence upon the phosphor used, if it is desired to pass the whole width of the phosphor emission band through the filter, since the narrower the pass band the more effective will be the arrangement of the invention in reducing the background luminance of the screen due to reflection of incident light.

In operation of the screen the phosphor emission, being randomly polarised, will also be partially absorbed by the circular polariser in the same manner as that proportion of the incident light which is diffusely reflected from the phosphor layer: thus again approximately 50% of the phosphor emission will be transmitted through the polariser to the screen face. This attenuation of the emission is, however, as regards visual effect, much more than offset by the improved contrast produced by the arrangement of the invention.

The screen viewing angle will be limited according to the width of the interference filter pass band: thus with a narrow bandwidth, for example 20 nm, it will be necessary to view the screen from a direction normal, or nearly normal, to the screen face, since at larger angles to the normal, the wavelength band of the light transmitted by the filter is altered. The narrower the pass band, the more restricted will the viewing angle be; if a wider view-

ing angle is desired, a filter with a broader pass band can be used, but with a resulting reduction in the screen contrast, as indicated above. Hence, in making a choice of interference filter, the respective requirements of viewing angle and degree of contrast must be balanced against one another.

A luminescent screen in accordance with the invention may be employed in various applications, for example in cathode ray tubes, X-ray screens, and image intensifiers, as well as in electroluminescent panels. This form of screen is particularly advantageous for use in an electroluminescent panel, in view of the usual relatively low level of luminance of the latter, which renders an improvement in contrast especially desirable for use in high ambient lighting conditions.

One or more additional layers may be incorporated in the screen structure if required. For example, in the case of an electroluminescent panel electrodes are provided on either side of the phosphor layer in the usual manner, in the form of a light-transmissive electrically conducting layer, usually tin oxide, in direct contact with the phosphor layer, between the latter and the interference filter, and one or more metal electrodes on the surface of the phosphor layer remote from the filter.

The transparent support plate or plates for the phosphor and light transmission modifying layers comprising the screen is or are usually formed of glass. However, transparent plastic materials may be employed in some cases, or for part of a screen support, provided that it is not necessary to use high temperatures in the fabrication of the screen or part thereof, as for example in the formation of a tin oxide layer in an electroluminescent panel, which layer is normally formed as a coating on a glass plate.

The screen support or substrate may, if desired, consist of only a single glass plate, with one or more of the required layers formed, in the order specified above, on each side. However, more than one transparent support plate may be used if desired; thus the screen may be built up, apart from the phosphor layer and back electrodes or any other components required on the side of the phosphor layer remote from the screen face, from commercially available units, each comprising a plate or film of glass or other transparent material carrying one of the required light transmission modifying layers. For example, an electroluminescent panel with high contrast screen may be fabricated by assembling together in a stack a glass plate with an anti-reflection coating on one side, a circular polariser in the form of a plate

or film of plastic material incorporating suitable polarising material, possibly supported on a glass plate, then an interference filter with a glass plate support, and finally  
 5 a glass plate with a tin oxide coating on the side remote from the filter, these components being bonded together by means of suitable optical cement layers, and then, in known manner, applying a phosphor  
 10 layer on to the tin oxide coating and forming the back electrode or electrodes on the phosphor layer. Preferably the arrangement is such that all the light transmission modifying layers are in contact with glass  
 15 plates; if any of these layers are in contact with material of refractive index different from that of glass, whether a different transparent material or another of said layers, the light transmission will be modified owing to the difference in refractive index, and modification of the design used may therefore be necessary.

The light transmission modifying layers may all be formed of conventional  
 25 materials whose anti-reflection, circularly polarising, and interference filtering properties, respectively, are well known. The materials used for the interference filter and their optical thicknesses will, of course, depend upon the wavelengths of the emission  
 30 band or bands of the phosphor employed. In the case of a phosphor exhibiting a single relatively narrow emission band, such as a zinc sulphide electroluminescent  
 35 phosphor, the interference filter will be formed of a combination of materials, allowing near-monochromatic light to pass therethrough.

Such narrow band interference filters are  
 40 known, and are formed from a multiplicity of layers of materials of high and low refractive index, deposited alternately on a substrate, examples of suitable combinations of materials being zinc sulphide and  
 45 magnesium fluoride, zinc sulphide and cryolite, titanium dioxide and silica, and zinc sulphide and thorium fluoride. Similar combinations of materials can also be used to form the broad band anti-reflection  
 50 coatings.

A luminescent screen in accordance with the invention may be of flat construction, as is usually the case with electroluminescent panels, or may be formed with slight  
 55 curvature, provided that the phosphor layer and the light transmission modifying layers are all parallel to one another and that the curvature is not sufficient to have an appreciable effect on the viewing angle as limited by the filter pass band, as explained above.

Several specific forms of construction of a luminescent screen in accordance with the invention are shown diagrammatically, in  
 65 section, in the drawings accompanying the

Provisional Specification, and will now be described by way of example.

In the drawings, which show, in greatly exaggerated thickness, portions of various  
 70 forms of an electroluminescent panel incorporating a zinc sulphide phosphor,

Figure 1 illustrates the principle of the invention, as applied to one form of the panel, and

Figures 2 to 5 inclusive show alternative  
 75 arrangements of the components of the panel, Figures 3, 4 and 5 being exploded to show the separate units which are assembled together in fabrication of the panel.

Like parts shown in the different Figures of the drawings are indicated by the same reference numerals.

Referring to Figure 1, the front surface of the panel consists of a broad-band anti-  
 85 reflection coating 1 on a glass plate 2, and on the back of the glass plate 2 there are a circular polariser 3, a narrow band-pass interference filter 4, a transparent layer of tin oxide 5, the phosphor layer 6, and a  
 90 back electrode 7, which is suitably formed of evaporated aluminium. The pass band of the interference filter 4 corresponds to the emission of the phosphor, which in the case of manganese activated zinc sulphide is a band approximately from 570  
 95 to 590 nm, giving narrow bandwidth yellow light.

In operation of the electroluminescent screen shown in Figure 1, incident light,  
 100 indicated by the lines 8, falling upon the face of the panel, passes through the coating 1, which cuts out nearly all specular reflection of the light, and through the glass plate 2 and the circular polariser 3, to  
 105 the interface between the polariser 3 and the filter 4, where all the light except that of the wavelength band corresponding to the filter pass band (represented by the line 9) is specularly reflected back into the  
 110 polariser and absorbed therein. The light in the pass band 9 passes through the filter 4 and tin oxide layer 5 to the phosphor layer 6, where it is diffusely reflected, approximately 50% of this light then being  
 115 absorbed in the polariser 3 and the remainder returning to the face of the panel, as indicated at 9'. The light emitted from one small portion of the phosphor layer is represented by the lines 10; approximately  
 120 50% of the phosphor emission will also be absorbed in the circular polariser 3.

Figure 2 shows an alternative arrangement of the panel components, in which the circular polariser 3 and the interference filter 4, as well as the anti-reflection  
 125 layer 1, are carried on the front face of the glass plate 2.

Figure 3 illustrates one manner in which the panel may be assembled, using initial 130

units consisting of (a) a glass plate 2 with an anti-reflection coating 1, (b) a circular polariser 3 in the form of a transparent plastic plate incorporating suitable polarising material, (c) an interference filter 4, and (d) a second glass plate 2' with a tin oxide coating 5. To form the panel, these units are bonded together, in the order shown, with an optical cement, and the phosphor layer 6 and back electrode 7 are then deposited on the tin oxide coating 5. Alternatively, an electroluminescent panel consisting of the glass 2' with tin oxide coating 5, phosphor layer 6 and back electrode 7 is first made in the usual way, and the components (a), (b) and (c) are then bonded to the front surface of the glass plate 2'.

Figures 4 and 5 show further modifications of the arrangement of initial units assembled together. Thus, in the arrangement of Figure 4, the interference filter is carried on an additional glass plate 2'', and in that of Figure 5 the polariser 3 and the filter 4 are supported on opposite sides of a glass plate 2'', in this case the polarising material suitably being incorporated in a celluloid film. It will be seen that, in both of these arrangements, all the light transmission modifying layers 1, 3 and 4 are in contact only with glass, except that the anti-reflection coating 1 is also in contact with the air.

In another possible alternative arrangement to those shown in Figures 3, 4 and 5, which is not shown in the drawings, the glass plate 2' may be omitted, the tin oxide coating 5 being formed directly on the interference filter 4.

The light transmission modifying layers employed in all the specific arrangements described above with reference to the drawings, namely the anti-reflection layer 1, the circular polariser 3 and the interference filter 4, can all be formed of commercially available materials whose uses for these respective purposes are known. Thus suitable combinations of materials chosen from those referred to above may be used for the anti-reflection layer and the interference filter, and the circular polariser may be of the type sold under the Registered Trade Mark "Polaroid".

The electroluminescent panels of the forms shown in the drawings are all encapsulated in a suitably controlled atmosphere: the encapsulation is of known form and is not shown in the drawings.

#### WHAT WE CLAIM IS:—

1. A luminescent screen comprising one or more plates of rigid transparent material and, supported on said plate or plates, a layer of phosphor and three layers each capable of modifying the transmission of light therethrough, which layers are disposed parallel to the phosphor layer and consist of firstly, disposed furthest from the phosphor layer and constituting the front face of the screen, a broad-band anti-reflection layer which is capable of preventing most of the specular reflection, from the front surface of the screen, of a wavelength band substantially corresponding to the visible spectrum, secondly a circular polariser, and thirdly, disposed nearest to the phosphor layer, a band-pass interference filter which permits the passage therethrough of light only of wavelengths corresponding to the whole or part of the emission of the said phosphor, the screen being so arranged that, in use, the incident ambient light falls directly upon the anti-reflection layer.

2. A luminescent screen according to Claim 1, which is an electroluminescent panel and includes also an electrode in the form of a light-transmissive electrically conducting layer in contact with the phosphor layer, between the latter and the interference filter, and one or more metal electrodes disposed on the surface of the phosphor layer remote from the said filter.

3. A luminescent screen according to Claim 1 or 2, in which the said light transmission modifying layers are incorporated in the form of units each comprising a plate or film of transparent material carrying one of said layers.

4. A luminescent screen according to Claim 1, 2 or 3, wherein all the said light transmission modifying layers are in contact with glass plates.

5. A luminescent screen according to Claim 1, constructed substantially as shown in, and as hereinbefore described with reference to, any one of Figures 1 to 5 of the drawings accompanying the Provisional Specification.

For the Applicants,

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Chartered Patent Agent.

1,389,737

PROVISIONAL SPECIFICATION

2 SHEETS

This drawing is a reproduction of  
the Original on a reduced scale.

SHEET 1

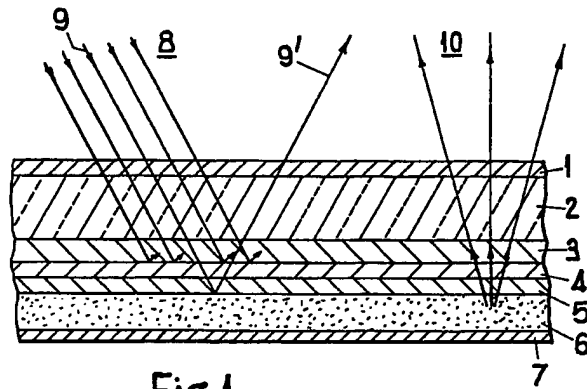


Fig. 1

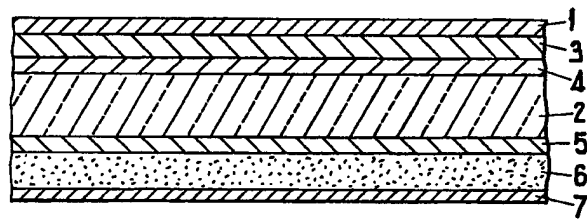


Fig. 2

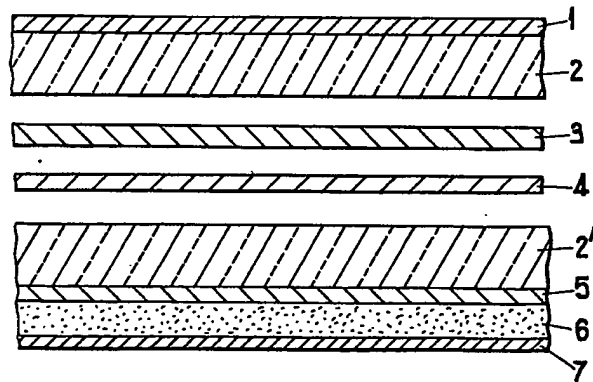


Fig. 3

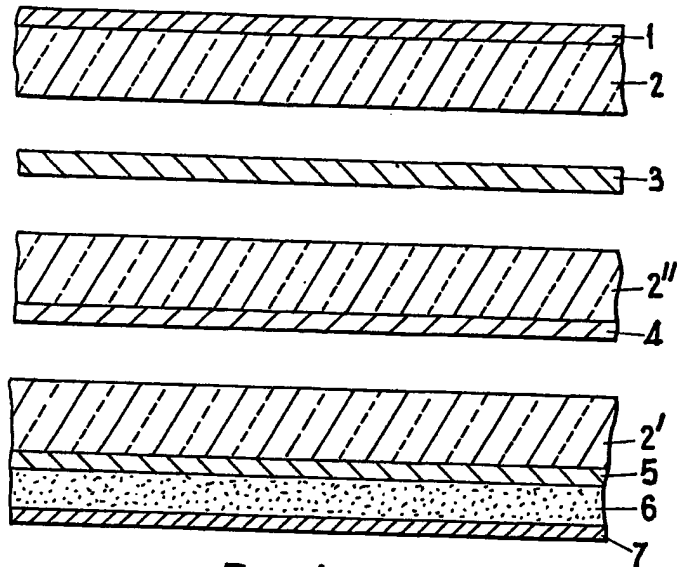


Fig. 4

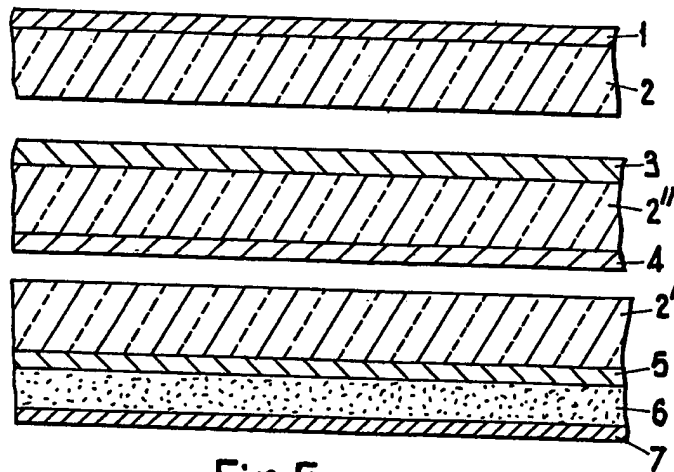


Fig. 5